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Changes in blood acid-base characteristics, haemoglobin and lactate concentrations due to increasing moderate stress in pigs

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Abstract. The effect of increasing moderate stress was studied in pigs. Therefore blood samples were analysed for acid-base characteristics, haemoglobin and lactate concentrations. The samples were collected from indwelling ear vein catheters that reached the vena cava cranialis. The first samples were taken from pigs (n = 10) that were at rest; the following samples were taken after five subsequent stages of increasing moderate stress. Stress consisted of fixation by maxillary sling that was combined with stimulation with an electric goad as the most severe kind of stress.

The subsequent stages of stress caused significant decreases in blood pH, base excess and, at lower level of significance, standard bicarbonate, while pCO_2 and lactate increased significantly. Changes in respiration rate were not observed.

It was concluded that stress caused a combined respiratory and metabolic acidosis, although both components of the acidosis may originate from changes in muscle metabolism.

Key words: acid-base balance, haemoglobin, lactate, blood, stress, pig.

Introduction. Stress, which has not necessarily to be considered as a negative situation (Selye, 1973), causes changes in blood concentrations of several metabolites, increases in haemoglobin and a shift towards acidotic in the acid-base balance of pigs (Kallweit, 1982). These changes can arise within a few seconds. It has already been found that puncture of the vena cava cranialis and fixation by maxillary sling were rather stressful to pigs (Bickhardt & Wirtz, 1968; Brenner et al., 1979). These procedures were accompanied by significant changes in blood acid-base equilibrium and lactate concentrations (Van der Wal et al., 1981).

The effect of stress on acid-base equilibrium and haemoglobin and lactate concentrations was studied in catheterized pigs which were subjected to increasing moderate stress.

Material and methods. Series of 6 blood samples were collected from 10 pigs with a live weight of about 100 kg. The pigs were provided with indwelling ear vein catheters that reached the vena cava cranialis (van de Wiel & Eikelenboom, 1977).

Control samples were taken from animals at rest (1), and the following samples were taken after the same animals were forced to stand (2), after placing a maxillary sling (3), after fixation with the sling (4), after prolonged fixation (5) and after fixation together with electrical stimulation with a goad (6). Sampling occurred from individually housed pigs, shortly after feeding at morning. Per pig the samples were taken within 5 to 12 minutes after start of the sampling. Blood acid-base characteristics, being pH, pCO_2 and pO_2, were determined within 3 hours after sampling in duplicate with Radiometer equipment. Further characteristics were calculated with Siggaard-Andersen alignment nomograms. The estimations of haemoglobin (TC 124729) and lactate (TC 124842) were performed with Boehringer, Mannheim, test kits. The statistical analyses on each of the variables were based on ranks within animals.

Results. Mean values and standard deviations of the variables that were determined in blood of pigs at rest and after the 5 stages of increasing moderate stress are given in Table 1. Blood pH decreased significantly, just as base excess (BE) and, at a lower level of significance, standard bicarbonate ($St.HCO_3^-$). Significant increases were found in partial CO_2 pressure (pCO_2) and lactate concentrations. The pO_2 remained nearly stable during the course of the experiments. The percentage of O_2 saturation slightly decreased, and the haemoglobin concentrations showed increases at the same time.

Discussion and conclusions. The subsequent stages of increasing moderate stress were characterized by decreases in pH which might be caused by an accumulation of CO_2 and/or metabolic processes that are reflected by decreases in BE. As blood pH and pCO_2 were highly significantly correlated, a respiratory acidosis was suggested to be present. No perceptible changes in respiration rate could be deduced from the pO_2 values. The O_2 saturation decreased slightly, which might be explained by the increases in haemoglobin concentrations. The total amount of CO_2 ($tot.CO_2$) was rather stable during the course of the experiments. Therefore the

Table 1. Mean values ($\bar{x}$) and standard deviations (SD) of acid-base characteristics and haemoglobin (Hb) and lactate concentrations (mmol/l) in blood of 10 pigs at rest and after 5 levels of increasing moderate stress.

Stress level →	1		2		3		4		5		6	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
pH	7.330	0.017	7.290	0.047	7.265	0.049	7.262	0.056	7.252	0.060	7.232	0.057
act.pO_2 kPa	4.15	0.43	5.31	4.25	6.57	5.63	5.04	4.20	4.42	2.22	4.94	4.25
O_2-sat. %	52.96	6.37	52.66	17.14	57.13	21.48	48.25	19.79	44.34	13.75	45.07	21.78
act.pCO_2 kPa	7.39	0.51	8.24	0.70	8.49	0.77	8.47	0.78	8.79	0.97	9.09	1.11
tot.CO_2 mmol/l	30.44	1.89	30.95	2.68	30.09	2.00	29.92	2.50	30.29	2.52	29.84	2.11
BE f.o. mmol/l	0.48	1.17	−0.20	2.93	−1.54	2.43	−2.21	3.13	−2.62	3.34	−3.27	2.96
st.HCO_3^- mmol/l	26.42	1.64	26.27	2.99	25.33	2.58	24.88	3.47	24.78	3.70	24.32	3.55
Hb mmol/l	6.97	0.71	7.05	0.39	7.52	1.14	7.59	0.57	7.85	0.66	7.74	0.75
lactate mmol/l	1.45	0.34	2.23	0.88	2.81	1.24	3.07	1.45	3.33	1.90	3.84	1.83

metabolic factor, being the HCO_3^- concentration, had to decrease since tot.CO_2 is a combined respiratory and metabolic factor and the respiratory factor pCO_2 increased significantly. It has to be noted that BE is a much better parameter for the metabolic component of the acid-base balance than HCO_3^- concentration (Rooth, 1969), while changes in the metabolic component towards acidosis can be provoked easily by lactate. The lactate concentrations increased significantly with the subsequent stages of stress, which could be explained by an inadequate supply of oxygen to the tissues. Therefore, it can be concluded that even moderate stress may cause significant changes in the acid-base equilibrium of pigs. These changes can be characterized as a combined respiratory and metabolic acidosis, although both components may originate from changes in muscle metabolism.

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